Notes on IWFM Version 2.4

(April 2006; Emin Can Dogrul; DWR)

IWFM Version 2.4 includes a modification to how water is allocated between deep percolation and runoff/return flow. The conceptual change is explained below. The code change is very minor. However, depending on the application, there may be a significant impact on the allocation of water between deep percolation and surface runoff/return flow.

In the process of calibrating C2VSIM (application of IWFM to the Central Valley of California) our consultants CH2M-Hill, Inc observed that deep percolation values simulated were a lot lower than expected based on previous studies, and were not explainable by parameter values governing the physical process. Careful examination of the theoretical basis in IWFM showed that the amount of deep percolation is limited by the amount of soil moisture between the “Total Porosity” and the “Field Capacity” limits, regardless of the amount of applied water and precipitation. A more realistic approach is to allow the deep percolation of the total of the applied water and precipitation that is in excess of the “Field Capacity”. When the new approach was implemented much more reasonable values were obtained. Therefore it was decided that the new approach will be adopted.

The new root zone routing scheme is explained in the following pages.

NEW ROOT ZONE MOISTURE ROUTING METHODOLOGY FOR IWFM

Definitions:

θ^{t+1}	=	soil moisture at the end of time step [L];
θ^{t}	=	soil moisture at the beginning of time step [L];
Δt	=	time step length [T];
I_P	=	infiltration of precipitation [L/T];
I_{AW}	=	infiltration of applied water [L/T];
ET	=	evapotranspiration [L/T];
D_p	=	deep perc after re-use [L/T];
A_W	=	applied water [L/T];
R_f	=	return flow of applied water after re-use [L/T];
R_U	=	re-used water [L/T];
K_s	=	saturated hydraulic conductivity [L/T];
FC	=	field capacity [L];
η_T	=	total porosity [L];
E_f	=	irrigation efficiency [dimensionless];
ρ	=	re-use factor as a fraction of the return flow [dimensionless].

Mass Balance Equation:

$$\theta^{t+1} = \theta^{t} + \left(I_P + I_{AW} - ET - D_p\right)\Delta t \leq FC$$

Let: $$\theta^{*} = \theta^{t} + \left(I_P + A_W\right)\Delta t$$

$$ET = ET\left(\theta^*\right)$$

$$\theta^{**} = \theta^t + \left(I_P + A_W - ET\right)\Delta t - FC$$

Now, compute deep perc, D_p:

$$D_p = \begin{cases} \min\left[K_s\left(\dfrac{\min\left(\theta^{**}, \eta_T\right)}{\eta_T}\right)^4 \quad , \quad \dfrac{\theta^{**}}{\Delta t}\right] & \text{for } \theta^{**} > 0 \\ 0 & \text{for } \theta^{**} \le 0 \end{cases}$$

Then, compute return flow, R_f:

$$R_f = \min\left[A_W,\ \max\left(\frac{\theta^{**}}{\Delta t} - D_p\ ,\ 0\right)\right]$$

Check, if the infiltration of precipitation needs to be decreased:

If $\quad D_p + R_f < \dfrac{\theta^{**}}{\Delta t}$ then

$$I_P = I_P - \left(\frac{\theta^{**}}{\Delta t} - D_p - R_f\right)$$

Finally, other terms can be computed as follows:

$$I_{AW} = A_W - R_f$$

$$R_U = \frac{R_f}{1-\rho}$$